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**Research Article**

# Effect of Drying Methods on the Chemical Composition and Anti-Nutrtional Properties of a Cocoyam (*Xanthosoma Maffafa* Schott) Tuber Flour and Leaf Powder

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**Abstract:** *Xanthosoma maffafa* Schott (XMS) is under-utilized cocoyam whose tuber and leaf have potential nutritional and functional benefit. This study evaluated the effect of sun and solar drying on the proximate, mineral and anti-nutritional content of XMS tuber and leaf. The result of the proximate composition showed significant ($p<0.05$) differences for moisture (5.70 – 7.20%), ash (2.10 – 7.80%), fat (0.90 – 6.40%), fibre (2.60 – 8.60%), protein (6.38 – 20.93%) and carbohydrate (49.38 – 81.83%) contents. The sun and solar dried leaf had 3-fold ash, 6-fold fat, 3-fold fibre and 3-fold protein than the sun and solar dried tuber sample. The mineral content ranged for calcium (151.93 – 204.73 mg/100g), magnesium (71.02 – 120.25 mg/100g), phosphorus (18.3 – 43.89 mg/100g), iron (4.70 – 7.89 mg/100g) and zinc (2.78 – 4.60 mg/100g), with the leaves having higher values than the tuber irrespective of the dying method. For anti-nutrients, the result showed significant variations. Tannin, phytate, phenol, oxalate and HCN ranged as follows: 0.55 - 1.11 mg/100g, 0.14 – 0.48 mg/100g, 0.22 – 0.43 mg/100g and 0.20 – 0.40 mg/100g, respectively. The leaf showed higher values of anti-nutrient compounds for both processing methods. The overall result revealed that XMS leaf is a richer source of nutrients than the tuber and that solar drying was preferred to sun drying not only for nutrient quality, but for better hygienic XMS products.

**Keywords:** *Xanthosoma mafaffa* Schott flour; Leaf powder; Sun drying; Solar drying; Nutrient quality; Anti-nutrients,



## INTRODUCTION

Cocoyam is one of the edible aroids and herbaceous perennial crop whose corms, cormels, leaves, stalks and inflorescence are utilized for food (Chukwu *et al*., 2008). Cocoyam is among the world's six most important root and tuber crops (FAO, 2012). Nigeria is rated the highest producer of cocoyam in the world with an annual production capacity of 3.450 million metric tonnes in 2012, representing 72.2 %, 57.7 % and 45.9 % of total production in West Africa, Africa and the World, respectively (Falade and Okafor (2015). It remains a neglected food resource despite its nutritional benefits (Falade and Okafor, 2015; Onyeka, 2014). Cocoyam have superior nutritional value over some other root and tuber staples, especially in terms of their protein content and digestibility, and minerals such as calcium, phosphorus and magnesium (Chukwu *et al*., 2008; Ekwe *et al*., 2009; Lim, 2016; Ukom and Okerue, 2018). Also the nutritional value of cocoyam leaf have been reported by various researchers. Cocoyam leaves are rich sources of protein, fiber, minerals, vitamin, antioxidants and dietary fiber (Ekwe *et al*., 2009; Lebot, 2009, Lewu *et al*., 2009; Adepoju and Olodu, 2016; Temesgen *et al*., 2016), and can be used as vegetables in sauces and soups in most West African countries (Acheampong *et al*., 2015). Cocoyam leaves are used to wrap and cook grated cocoyam or water yam, especially for preparing a special delicacy called *Ekpang Nkwukwo.*

*Xanthosoma* (Taro) and *Colocasia* (Tania) are two edible species of cocoyam with many varieties (Ukom and Okerue, 2018). *Xanthosoma mafaffa* Schott (XMS), a variant of *Xanthosoma* is a lesser known cocoyam despite its nutritional and potential food applications (Ukom *et al*., 2019). XMS is rich in proteins, minerals, carotenoid, xanthophylls, polyphenols, flavonoids, and has strong antioxidant activity assayed in DPPH (2,2-diphenyl-1-picrylhydrazyl), ABTS (2, 2-azino-bis-(3-ethybenzothiazoline-6-sulphonicacid) diammonium salt and ORAC (Oxygen radical absorbance capacity) (Ukom *et al*., 2014a; Ukom *et al*., 2014b; Ukom and Okerue, 2018). The tuber of XMS can be processed into flour for use in production of bakery products, or cooked and pounded together with boiled cassava paste into *fufu* and eaten with soup (Ukom *et al*., 2019). A major drawback to the food use of cocoyam is the presence of anti-nutrients, particularly, oxalate and phytate that are found in all of the plant parts (Sefa-Dedeh and Agyir-Sackey, 2004; Ramanatha *et al*., 2010). They interfere with processes such as digestion, absorption and utilization of nutrients such as proteins and minerals. Phytate chelates with metal ions such as calcium, magnesium, zinc, and iron to form poorly soluble compounds that are not readily absorbed in the intestine, thus interfering with the bioavailability of these essential minerals (Gebrelibanos *et al*., 2013). Possible health problems associated with anti-nutrient toxicity of cocoyam includes gastrointestinal and neurological disorders, pancreatic enlargement and growth depression, neuropathy and even death (Soetan *et al*., 2014). Processing methods degrade anti-nutrients content of foods. Drying as a food processing method cause changes in the food properties, especially in the texture, nutritive value, changes in physical appearance and shape, and in the reduction of anti-nutrient content to appreciable levels (Amandikwa, 2012).

The main objective of this study was to evaluate the effect of sun and solar drying methods on the proximate, minerals and anti-nutrient properties of *Xanthosoma mafaffa* Schott (XMS) tuber flour and leaf powder.

## MATERIALS AND METHODS

**Sources of raw materials**

Cocoyam (*Xanthosoma mafaffa* Schott) tubers and leaves (Fig 1.) were procured from a local farm at Ikot-Ekpene, Akwa Ibom state in good physiological condition. All reagents used for analysis were sourced from Biochemistry Laboratory of National Root Crops Research Institute, Umudike, Abia State.

**Sample preparation and production of *Xanthosoma mafaffa* Schott tuber flour**

*Xanthosoma mafaffa* Schott tuber was processed into flour using the method described by Ukom and Okerue (2018) with modification (Figure. 1). XMS tuber were manually peeled, sliced into 2 cm and washed in water. Thereafter, they were divided into two portions. One portion was dried in the sun for 48 h while the other portion was dried in solar dryer for 72 h. They were separately milled using attrition mill and sieved through 0.42 mm mesh size sieve to obtain sun and solar dried XMS flour, respectively. The flours were separately packaged in a polyethylene pack till further use.

**Production of *Xanthosoma mafaffa* Schott leaf powder**

*Xanthosoma mafaffa* Schott leaf powder was processed as shown in Figure 2. The leaf was washed in clean tap water and drained. It was divided into two parts. The first part was sun dried for 48 h while the second part was solar for dried 72 h. Each dried portion was separately pulverized to obtain sun and solar dried XMS leaf powder. It was packaged in a clean polyethylene pack till further use.

Whole XMS tuber

Sun dried XMS shredded Leaf

**Fig.1:** XMS Tuber and dried shredded Leaves

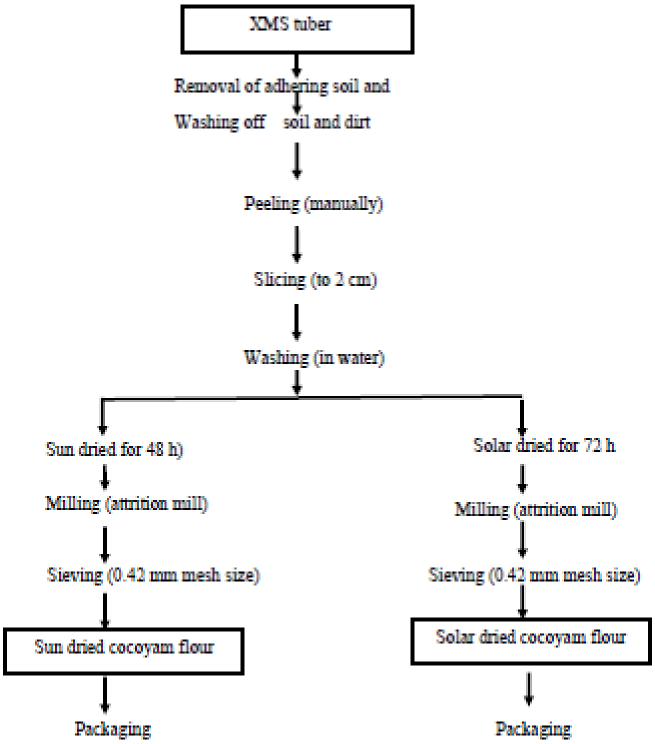


**Fig.1a:** Flow chart for the production of *Xanthosoma mafaffa* Schott (XMS) flour
*Source:* Ukom and Okerue (2018)

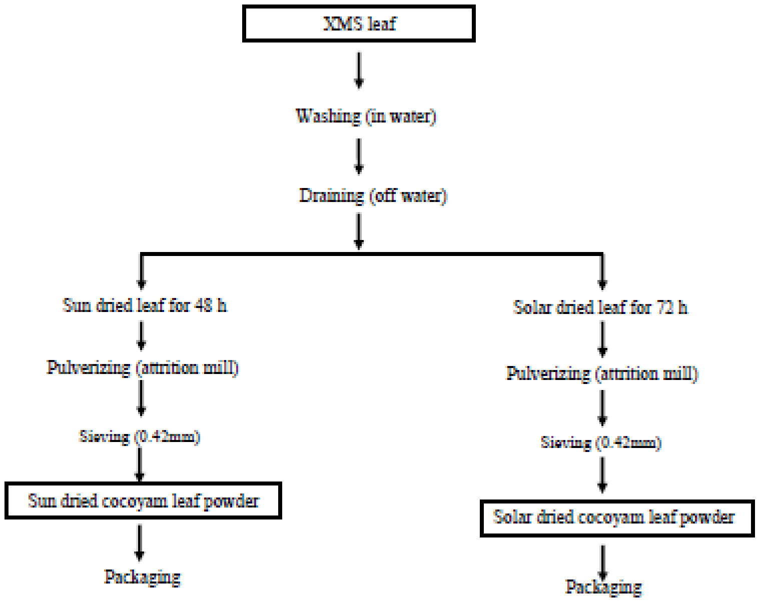


**Fig. 1b:** Flow chart for production of *Xanthosoma mafaffa* Schott (XMS) leaf

**Determination of the proximate composition of XMS tuber flour and leaf powder**

The method of AOAC (2005) was used. The crude protein (Kjeldahl method %N x 6.25), crude fat (Soxhlet method: hexane boiling point 40 to 60 $^0$C), crude ash (Muffle furnace, 550 $^0$C), fibre, moisture (Hot air oven, 105 $^0$C) and carbohydrate content was calculated by difference.

**Determination of mineral composition of XMS tuber flour and leaf powder**

The mineral content of the samples were determined by the dry ash extraction method (James, 1995). Phosphorus was determined by the vanadomolybdate (yellow) spectrophotometry (Jenway electronic spectrophotometer at wavelength of 420 nm). Calcium and magnesium were determined by complexiometric versanate EDTA titrimetric method (AOAC, 2005). Zinc was determined by the method of

AOAC, (2005), while iron was determined by the method of Achikanu *et al*. (2013)

**Determination of the Anti-nutrients of XMS tuber flour and leaf powder**

Spectrophotometric method was used for the determination of phytate (AOAC, 2005). The method described by Nwosu (2011) was used to determine the tannin content of the samples. The method of Onwuka (2018) was used for the determination hydrogen cyanide Content, while the phenolic content was determined by using Folin- Ciocalteu reagent according to the method of Odabasoglu *et al*. (2004).

**Statistical analysis**

One Way Analysis of Variance (ANOVA) in a completely randomized design using the SPSS version 22 was carried out (duplicates) to compare between mean values, while treatment means was separated using Duncan multiple range test at 95% confidence level (p<0.05).

## RESULTS AND DISCUSSION

**Effect of drying methods on the proximate composition of XMS tuber flour and leaf powder**

Table 1 shows the result of the proximate composition of the tuber flour and leaf powder of *Xanthosoma maffafa* schott as affected by drying method. The proximate results showed significant (p>0.05) variations in all the parameters analyzed. The moisture content ranged from 5.70 – 7.20%. Although the moisture content was low due to The effect of drying on free moisture in these samples, the leaf powder and sun dried method showed higher moisture values than the tuber and solar dried method. The moisture values are comparable to the range of 6.17 – 7.88% reported by Ukom and Okerue (2018) for *Xanthosoma sagittifolium* flour cultivar. Drying is important method in food preservation that is aimed at improving the shelf stability of foods and increase their dry matter content.

The results of the ash content of the leaf powder showed higher significant (p<0.05) difference than the tuber sample. The ash content ranged from 2.10% to 7.80%. In this study, XMS leaf powder was higher in ash concentration than the tuber flour. On the drying method, ash content of the solar dryer was marginally higher than that of sun dried method. Value obtained for the tuber flour was within the range reported for *Xanthosoma sagittifolium* flour cultivar (Ukom and Okerue, 2018), But were higher than 2.66 - 3.49 g/100gdw reported by Amah et al. (2018) on *Xanthosoma sagittifolium* white and red varieties.

The fat content of the sun dried and solar dried tuber flour were 0.90% and 1.00%, while that of the leaf powder were 6.30% and 6.40%, respectively. There was no significant difference (P>0.05) in the fat value for sun dried and solar dried tuber flour and for solar dried leaf powder respectively. This implies that drying method did not affect the fat content of the *Xanthosoma mafafa* Schott tuber flour and leaf powder. The tuber flour fat was higher than 0.65% reported for *colocassia esculaenta* (Alcantara *et al*., 2013), but was lower than 1.15 – 3.22% reported by Ukom and Okerue (2018) for *Xanthosoma sagittifolium* flour. This variation could be attributed to variety, season of harvest and method of processing. Much higher values (9.82 – 12.17%) was reported for seven accessions of cocoyam leaves (Lewu *et al*., 2009) and 5.84 – 6.44% as reported by Temsgen *et al*. (2016) for the leaves of *colocasia esculenta*. This study has shown that cocoyam tuber flour and leaf powder have moderate lipid content, and may be of advantage to people on low energy diet.

The fibre content of the tuber flour was lower than that of the leaf powder. Although the fibre content of solar dried leaf powder (8.60%) and sun dried leaf powder (8.30%) were higher than solar dried tuber flour (2.90%) and sun dried tuber flour (2.60%), the solar dried tuber flour and solar dried leaf powder fibre were significantly higher than sun dried tuber flour and sun dried leaf powder. This is because vegetables have high fibre content than tubers. However, the fibre content of the tuber flour is higher the value of 1.31 – 1.93 g/100gdw obtained by Amah *et al.* (2018) on white and red varieties of *Xanthosoma sagittifolium*. Fibre as a part of diet help to cleanse the digestive tract, prevents the absorption of excess cholesterol and removes potential carcinogens from the body. Fibre also adds bulk to food, helps to attenuate blood glucose level and reduce the effect of physiological health disorders such as hypertension and diabetes mellitus.

The protein content of the samples varied significantly and ranged from 6.38 - 6.75% for sun dried and solar dried XMS tuber flour and 19.58 - 20.93% for the sun dried and solar dried leaf powder. Comparatively, higher protein value was obtained for solar dried leaf powder and tuber flour than the sun dried samples. The protein content obtained from the tuber flour is comparable to the value of 5.30 – 6.80% reported for cocoyam (Ukom *et al*., 2018), But was lower than 4.33 – 5.92% for *X. sagittifolium* cultivar reported by Ukom and Okerue (2018), and 3.50 – 4.72 g/100gdw reported by Amah *et al.* (2018) on red and white varieties of *Xanthosoma sagittifolium*. Also, the leaf powder protein content was lower than 25.71 – 28.61% reported for seven accessions of cocoyam leaves (Lewu *et al*., 2009) and 25 - 26% for *colocasia esculenta* leaves (Temesgen *et al*., 2016).

The carbohydrate content ranged from 49.38 – 81.83%. Significantly higher values of carbohydrate was obtained for the tuber flour than for the leaf powder. This is not surprising as tuber crops contain high levels of carbohydrate. The carbohydrate content of the tuber flour was 38-40% higher than the leaf power content. Comparatively, carbohydrate was higher in sun dry than in the solar dry method. The carbohydrate content reported in this study is much lower than 386.7% dw reported by Temsesgen et al. (2016).

**Table 1:** Effect of drying method on the proximate composition of XMS tuber flour and leaf powder (%)

| Samples | Moisture | Ash | Fat | Fibre | Protein | CHO |
|---|---|---|---|---|---|---|
| $SDT_1$ | $6.20^c\pm0.0$ | $2.10^b\pm0.14$ | $0.90^b\pm0.4$ | $2.60^d\pm0.00$ | $6.38^c\pm0.18$ | $81.83^a\pm0.11$ |
| $SDT_2$ | $5.70^d\pm0.14$ | $2.40^b\pm0.00$ | $1.00^b\pm0.00$ | $2.90^c\pm0.14$ | $6.75^c\pm0.00$ | $81.25^a\pm.28$ |
| $SDL_1$ | $7.20^a\pm0.00$ | $7.60^a\pm.28$ | $6.30^a\pm0.14$ | $8.30^b\pm0.14$ | $19.58^b\pm0.25$ | $51.25^b\pm0.03$ |
| $SDL_2$ | $6.90^b\pm0.63$ | $7.80^a\pm0.00$ | $6.40^a\pm0.10$ | $8.60^a\pm0.00$ | $20.93^a\pm0.18$ | $49.38^c\pm0.32$ |

Values are mean ± SD. Values on the same column with different superscripts are significantly different (P<0.05). Key: $SDT_1$ =Sun dried tuber, $SDT_2$ = Solar dried tuber, $SDL_1$ = Sun dried leaf, $SDL_2$ = Solar dried leaf

**Effect of drying method on the mineral composition of XMS tuber flour and leaf powder**

Table 4.2 presents the result of the mineral composition of XMS tuber flour and leaf power as affected by drying method. The result showed significantly (P<0.05) higher mineral content in the leaf powder than in the tuber flour irrespective of the drying method. The calcium, magnesium, phosphorus, iron and zinc content ranged from 151.93 – 204.73 mg/100g, 71.02 – 120.25 mg/100g, 18.03 – 43.89 mg/100g, 4.70 – 7.89 mg/100g and 2.78 – 4.60 mg/100g, respectively. Temesgen *et al*. (2016) and Lewu et al. (2009) had reported that cocoyam leaves are rich sources of micro and macro elements. Overall, solar dried leaf power and tuber flour had higher mineral content than the sun dried leaf power and tuber flour. This implies that solar drying method conserved more mineral nutrient than the sun drying method. Comparing with other researchers, Ukom and Okerue (2018) reported lower calcium, magnesium, phosphorus, and zinc content, but higher iron content in *Xanthosoma sagittifolium*, Also, Temesgen *et al*. (2016) obtained higher zinc (9.77 – 1075%dw) and iron (40.4 – 51.7%dw) content, but lower calcium (15.26 – 15.89%dw), magnesium (8.3 – 8.5%dw), and phosphorus (1.2 – 1.4%dw) in *Colocasia esculenta* leaves. Minerals nutrition are very important to the body. Calcium is necessary for supporting bone formation and growth. Magnesium is essential to good health because it helps to maintain normal muscle and nerve function, keeps heart rhythm steady, supports a healthy immune system and keeps bones strong. Phosphorus works closely with calcium to build strong bones and teeth. Zinc is a trace element that is important in digestion and physiological functions that protects the liver organ from chemical damage. Iron is required for haemoglobin production for oxygen transport from the lungs through the blood vessels to the tissues.

**Table 2:** Effect of drying method on the mineral composition of XMS tuber flour and leaf powder (mg/100g)

| Samples | Ca | Mg | P | Fe | Zn |
|---|---|---|---|---|---|
| $SDT_1$ | $151.93^d\pm0.25$ | $71.02^d\pm0.24$ | $18.03^d\pm0.53$ | $4.70^d\pm0.00$ | $2.78^d\pm0.04$ |
| $SDT_2$ | $154.85^c\pm0.00$ | $73.24^c\pm0.50$ | $19.14^c\pm0.00$ | $5.13^c\pm0.08$ | $3.18^c\pm0.00$ |
| $SDL_1$ | $196.11^b\pm0.00$ | $117.06^b\pm0.59$ | $41.99^b\pm0.26$ | $7.22^b\pm0.00$ | $4.15^b\pm0.14$ |
| $SDL_2$ | $204^a\pm0.81$ | $120.25^a\pm0.54$ | $43.89^a\pm0.00$ | $7.89^a\pm0.00$ | $4.60^a\pm0.79$ |

Values are mean ± SD. Values on the same column with different superscripts are significantly different (P<0.05). Key: $SDT_1$ =Sun dried tuber, $SDT_2$ = Solar dried tuber, $SDL_1$ = Sun dried leaves, $SDL_2$ = Solar dried leaves

**Effect of drying method on the anti-nutrient composition of XMS of tuber flour and leaf powder**

Table 4.3 presents the result of the anti-nutrient composition of the tuber and leaf of *X. maffafa* as affected by drying methods. The result shows that the anti-nutrients composition in the samples varied in the following range; tannin (0.55 – 1.11 mg/g), phytate (0.14 – 0.42 mg/g), phenol (0.06 – 0.85 mg/g), oxalate (0.22 – 0.43 mg/g) and HCN (0.20 –0.40 mg/g). Higher values were obtained in the Leaves than the tuber flour. Lower values were obtained in the solar dried samples than in the sun dried once. This shows that solar drying decreased the anti-nutrient content of the tuber and leaf of *Xanthosoma maffafa* Schott more than in sun drying. However, there was no significant difference (P<0.05) in the values obtained for sun dried and solar dried tubers. Temesgen *et al*. (2016) reported higher oxalate (198.61 - 257.92 mg/100g), phytate (8.59 – 9.88 mg/100g) and tannin (419. 80 – 504.24 mg/100g) contents when compared to the value obtained in this study. Ukom and Okerue reported higher oxalate content (10.2 -95.5 mg/100g), comparable phytate content and lower tannin (0.0 – 0.42 mg/100g), phenol (0.0 – 0.2 mg/100g) and HCN (0.82 – 3.74 mg/100g) contents when compared to the value obtained in this study. Tannin is said to have some antibacterial, antiviral and anti-parasitic effects (Akiyama *et al*., 2001). Excessive ingestion of cyanogenic glycosides can be lethal as it intercalates with cytochrome oxidase and affect aerobic function (Akiyama *et al*., 2001). The values obtained in this work were very low (0.08 – 0.76 mg/100g) and therefore safe for human consumption. Phytate and oxalate are anti-nutritional factors which are present in various food sources and play detrimental role when consumed in higher amount. High concentrations of anti-nutrients have shown to affect mineral bioavailability in foods by forming complexes with them, and as a result reduce their absorption and utilization by the body systems (Adane et al., 2013). The phytate and oxalate values in the XMS are lower than the lethal dose (450 mg), and hence will not elicit toxic effect when consumed.

**Table 3:** Effect of drying method on the anti-nutrient composition (mg/100g) of XMS tuber flour and leaf powder

| Samples | Tannin | Phytate | Phenol | Oxalate | HCN |
|---|---|---|---|---|---|
| $SDT_1$ | $0.68^b \pm 0.04$ | $0.49^c \pm 0.03$ | $0.10^c \pm 0.03$ | $0.26^c \pm 0.04$ | $0.24^b \pm 0.01$ |
| $SDT_2$ | $0.55^b \pm 0.04$ | $0.14^c \pm 0.04$ | $0.06^c \pm 0.00$ | $0.22^c \pm 0.00$ | $0.20^b \pm 0.01$ |
| $SDL_1$ | $1.11^a \pm 0.16$ | $0.42^a \pm 0.02$ | $0.85^a \pm 0.00$ | $0.43^a \pm 0.00$ | $0.40^a \pm 0.01$ |
| $SDL_2$ | $1.08^a \pm 1.08$ | $0.34^b \pm 0.04$ | $0.71^b \pm 0.00$ | $0.35^b \pm 0.00$ | $0.37^a \pm 0.02$ |

Values are mean ± SD. Values on the same column with different superscripts are significantly different ($P<0.05$). Key: $SDT_1$ =Sun dried tuber, $SDT_2$ = Solar dried tuber, $SDL_1$ = Sun dried leaves, $SDL_2$ = Solar dried leaves

## CONCLUSION

This study was undertaken to determine the effect of drying methods on the nutrient content of XMS tuber flour and leaf powder. The results showed that the tuber flour and leaf powder of *Xanthosoma maffafa* Schott (XMS ) were rich sources of nutrients. The leaf powder of XMS had higher ash, fat, fiber, protein and mineral contents than the tuber flour. The results also revealed that solar drying method was a better processing method in terms of nutrient retention and anti-nutrient reduction than sun the drying method. Going by the nutrient quality of XMS leaf powder, it can be used as a supplement in human and animal meals for improved nutrition. Also solar drying method can be used to process XMS products for preservation to ensure availability in hygienic and stable condition.

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